DRAFT

Bay Area EcoAtlas
Narrative Documentation

Version 1.50b4

San Francisco Estuary Institute
July 1998

IMPORTANT NOTE TO READERS
22 July 1998

This version of the Narrative Documentation of the EcoAtlas is provided to members of the EcoAtlas betatest group in draft format. Substantial sections have not yet been completed. At this time, the document will be most useful to answer general questions about the Native Landscape View. Additional documentation, especially for the Modern Landscape View, is in preparation and we will provide updates as soon as they are available.

Documentation of native landscape coverages is organized as follows:

GIS AT SFEI

Geographic Information Systems are integral components of the SFEI programs for bays, wetlands, and watersheds. The centerpiece of the GIS at SFEI is the Bay Area EcoAtlas. The EcoAtlas is emerging as the “base map” for local and regional environmental planning and protection. The EcoAtlas has been developed through extensive public participation and abundant partnerships with local agencies, non-governmental organizations, and university programs. It is expected to become a primary communications tool to visualize and share information about local ecosystems.

SFEI's primary GIS applications are currently running on a NekkoTech Workstation with a DEC Alpha 300 MHz processor, 256RAM, 16gb of internal hard drive space and external Iomega Jaz drives. Other hardware includes a Mayline digitizer table and an Encad NovaJet Pro wide-format plotter. Software operated on this platform includes ESRI's ArcInfo, Tin and Grid applications, GRASS and Fragstats. Windows GIS applications include ArcView and MapInfo.

ECOATLAS CORE PERSONNEL

Elise Brewster, M.L.A, M.F.A.	Research Associate
Joshua N. Collins, Ph.D.	Environmental Scientist
Zoltan Der	Environmental Analyst
Robin Grossinger, M.S.	Assistant Env. Scientist
Christina Wong	Environmental Analyst

Bay Area EcoAtlas Documentation
Version 1.50

Visit the Bay Area EcoAtlas at the SFEI web site at http://www.sfei.org

Overview

This report is intended to support version 1.50 of the Bay Area EcoAtlas©. This first section provides a general description of the EcoAtlas and its anticipated uses as a tool for regional ecological planning and management. Subsequent sections document the Historical and Modern Views of the EcoAtlas. Metadata documents for each View are provided in the Appendix.

DESCRIPTION OF THE BAY AREA ECOATLAS

The Bay Area EcoAtlas© is a computer-based Geographic Information System (GIS) of past and present local ecology. It is designed to support local and regional environmental planning and management. The EcoAtlas represents the integration of many kinds of information from numerous sources, to compile a picture of the environmental past, the present, and change. It provides the most detailed regional views of past and present ecological conditions that are available at this time. It is also a spatial template to view possible scenarios for environmental management in the future, and a geographic index for spatially-related environmental data and their sources.

The EcoAtlas is a growing concern. Planning is ongoing to assure its accuracy, maximize its availability to the public, and enable reputable sources to add local or regional information. It is envisioned that anyone will be able to use the EcoAtlas to exchange information about local and regional ecology. It is hoped that the EcoAtlas will enhance the regional sense of place and purpose.

SFEI has copyright status to help maintain the integrity of the EcoAtlas as a common platform for environmental planning and protection throughout the Bay Area. SFEI will endeavor to make new versions of the EcoAtlas available as quickly and easily as possible, while maintaining interagency consensus and the highest standards of science.
The EcoAtlas is managed by SFEI as a set of maps and related images and information. The maps are called coverages. Each coverage consists of one or more unique features, or places. All coverages and their features share a common system of geographic coordinates. This allows features to be selected to view and measure, and it allows one coverage to overlay another. Aerial photography and other plan-view images are separate overlays. Related information includes databases describing each habitat and its functions, species distribution and abundance, and extensive GIS metadata that document the technical aspects of the coverages.

Acknowledgments

The creation of the EcoAtlas has been possible largely because of the efforts of numerous Bay Area residents who have contributed information about historical and present-day ecological conditions. Thus far more than 200 volunteers from throughout the region have contributed over 10,000 hours of volunteer time. Without the talent and dedication of local volunteers, the detail and accuracy of the EcoAtlas would not be possible.

Thus far, to create the EcoAtlas Native Landscape View, twenty-six interns have worked intensively at SFEI to identify, collect, and organize historical data. A number of interns worked on focused research or archival projects for three or more months. These interns are listed below.

Intern	Project
Ann Baker	Alameda County
Katie Bickell	Spanish Land Grant Cases, Redlegged Frog Industry
Margot Cunningham	Contra Costa County, Alameda County, Data Management
Zoltan Der	San Mateo County, Data Management
Spence Everson	Santa Clara County
Arlie Haig	GIS Development
Corrine Humphrey	Data Management
Maggie Hynes	Marin County
Ellie Insley	Sonoma County
Rebecca Johnson	Spanish Land Grant Cases
Steve Jones	Contra Costa County
Alan Kaplan	Solano County
Isaac Shukima	Spanish Documents
Katy Suttorp	Native Land-Use, Freshwater Influences on Tidal Marsh
Dennis Worrell	Early Soil Surveys

In addition to the interns who worked on focused research projects, there were other interns who were especially valuable because they provided many hours of volunteer service on many different aspects of the Native Landscape View. These interns are listed below.

Linda Barber
Todd Barber
Deborah Carol
Emily Cheng
Skip Hunter
Stacy McGihan
Robert Mendez
Phil Mittenberg
Tom Radulovich
Leslie Stansfield
Carrie Steenwerth
Andrea Subotic
Nandini Venkatesh

THE ECOATLAS NATIVE LANDSCAPE VIEW

This section documents each habitat type mapped in the Native Landscape View. The *General Methodology* section summarizes the process used to create the Native Landscape View. In the second part, *Historical Coverage Descriptions*, major and minor sources of data are described, qualifications or limitations to each coverage explained, and written illustration of some types provided from the historical record. Reference sites and graphic illustrations will be incorporated at a later date. The third part, *Most Questionable Places*, describes several places which are less well understood than the rest of the picture but may have local or regional ecological significance.

General Methodology

Overview

While a tremendous amount of information about the historical landscape has been gathered by a team of student researchers, academic and agency scientists, citizen volunteers, and SFEI staff, we suspect that as much or more knowledge about the past landscape will emerge from local communities in the future. We are establishing protocols to allow the EcoAtlas to grow through local efforts, resulting in updated versions and new understanding.

The Native Landscape View of the EcoAtlas is a composite picture based upon approximately 1000 independent sources of data. These include eighteenth- and nineteenth-century maps, sketches, paintings, photographs, engineering reports, oral histories, explorers' journals, missionary texts, hunting magazines, interviews with living elders, and other sources. Documents were selected from tens of thousands of materials examined at archives around the Bay Area and are catalogued in the project databases. Sufficient information about the native Bay Area landscape is available from early European documents to discover the distribution and abundance of many habitat types with confidence. With a robust amount of data, historical sources overlap and confirm (or contradict) each other, strengthening their interpretation. The intersection of discrete sources is then mapped and recorded in a database. This is the basic procedure used to compile the Native Landscape View of the EcoAtlas.

While the Native Landscape View likely approximates pre-European conditions at a regional scale, with substantial local detail, it must be emphasized that substantial uncertainty may be present at a local scale. As part of the process of integrating data to form the composite picture, the relative certainty of each feature (e.g. a creek, marsh, or pond) has been recorded according to quantitative or qualitative standards (see Table 1) for presence, size, and location. The amount of uncertainty ranges, with regard to location, from 100 ft to 1 mile; with regard to size, from 10% to 100%; and with regard to actual presence, from “definite” to “possible.” These individually coded attributes will enable EcoAtlas users to query the estimated amount of uncertainty associated with different places in the map, based on SFEI’s scholarship. However, the Source and Certainty Tables have not been completed to the point of linkage to the EcoAtlas at this time. As a result, a wide range of certainty levels are concealed electronically in the

Native Landscape View. **Some features may appear in the EcoAtlas as far as one mile from their true historical locations, as much as half their true size, and/or may not be strongly supported (but suggested) by the evidence.**

To provide guidance to the user until Source and Certainty Tables for the EcoAtlas are available, a general description of the origin of each coverage and the uncertainty currently associated with each type of feature is given in the following sections.

Table 1. Certainty Level Standards

Certainty Level	Presence of Feature	Size of Feature	Location of Feature
High	Presence well-supported: "Definite"	Size well-controlled (+/- 10%)	Location well-controlled (within 500 feet)
Medium	Presence well-supported, with some qualification(s): "Probable"	Size not well-controlled but evidenced (+/- 50%)	Location not well-controlled (within 2000 feet)
Low	Presence not well-supported: "Possible"	Size not well-controlled and not evidenced (defined case by case)	Location not well-controlled (within 1 mile)

Native Landscape View Methods

Geomorphic definitions of these features are available in the description of the Habitat Typology in Appendix__.

BAYS AND CHANNELS

Deep Bay or Channel

(documentation in progress)

Shallow Bay or Channel

(documentation in progress)

BAYLANDS

Sandy Beach

Major Sources
1. United States Coast Survey Topographic Sheets, 1850's.

Minor Sources
1. Land Grant Surveys.
2. Early Aerial Photography
3. Late 19^{th} Century Landscape Paintings

Data Interpretation and Integration: Sandy beaches are well-defined on historical USCS maps by cartographic symbols (stippling) conventionally used to represent sand (Shallowitz, 1964). Local land-grant surveys provide supporting data in the form of written descriptions (e.g. "sandy beach") in some places. Early aerial photography and landscape paintings also confirm the interpretation of USCS cartographic symbols as sandy beach. These habitats are generally adjacent to tidal marshlands or tidal lagoons. Beaches narrower than 50 feet are shown as a color-coded line rather than a polygon.

Data Uncertainty and Future Development
The USCS T-sheets of the 1850's form a nearly complete picture of the shoreline during this era, prior to most Eurogenic modifications, including Sierran hydraulic mining debris. As a result, the picture of sandy beach is geographically robust and generally highly accurate.

For spatial analysis, buffer polygons were created around the beaches which are represented as arcs in the Native Landscape View. The width of the buffer was based on the average of X of these beaches, or X m.

Certainty of Presence: Mostly High
Certainty of Size: For polygon features, high; for linear features, not applicable.
Certainty of Location: Mostly High.

Tidal Flat

Major Sources
1. United States Coast Survey Hydrographic Sheets, 1853-1867
2. United States Coast Survey Topographic Sheets, 1850-1866

Minor Sources
1. United States Navy Navigational Charts, 1850
2. United States Geological Survey Quadrangles, Napa, 1902
3. United States Coast Survey Topographic Sheets, 1886-1898

Data Interpretation and Integration
The Tidal Flat coverage reflects greater uncertainty than most others for two reasons. The first is the technical difficulty of delineating the line of MLLW. Secondly, tidal flats, particularly in Suisun, are more likely to have experienced significant effects from Sierran hydraulic mining debris by the time of the first USCS work. Uncertainty increases towards Suisun (25-30%) and along some tidal marsh channel networks which are not well documented. Our work reconstructing the historical extent of tidal flats is much assisted by recent USGS research on sedimentation changes in the Estuary (Jaffe, et al. 199?).
Tidal flats are conventionally defined on their bayward margin by the line of MLLW and on their landward margin by the lower limit of tidal marsh vegetation; or if no marsh is present, the natural or artificial edge of dry land. The approach used to define MLLW by early surveyors is explained by Shallowitz, in his authoritative text about the interpretation of USCS surveys:

> Both to the hydrographer and the topographer, the low-water line is one of the most uncertain and difficult features to delineate. Unlike the high-water line [which is evidenced by wrack lines, plant distribution, and other visible indicators], it is actually visible but momentarily to the topographer. If located by the hydrographer it must generally by accomplished when the height of the tide is well above low water, making it difficult to develop readily its many irregularities. It was, therefore, recognized at a very early period in the work of the Survey that the determination of the low-water line must be left for its final delineation to boteh parties, 'everyone to work according to his best knowledge, and compare afterwards.' . . . [T]he chart compiler, cognizant of the limitations of both methods of surveying, should use his best judgment in selecting the portion to be taken from each survey for the delineation of the low-water line on his chart. (Shallowitz 1963, pp183-184)

The line of MLLW as delineated by the topographic and hydrographic teams is dramatically different in places, despite often being surveyed in the same year. Following Shallowitz, we use the H-sheets to define MLLW along the shores of the open bays and the T-sheets along rivers and sloughs in tidal marshlands. In the open bays, the hydrographic team's work is most accurate because they were able to make soundings up to or even across the horizontal position of MLLW, while the topographic team had to sketch areas often quite far away from their vantage point on adjacent land or marsh. However, the H-sheets work rarely extend along tidal channels into the marshlands. Fortunately, tidal flats along major rivers (e.g. Petaluma, Napa) and channels were likely accurately surveyed by the topographic team. Because of their work surveying adjacent tidal marshlands, the topographic team had established good horizontal control over the slough margins, and was able to observe the limits of low tides over several tidal cycles.
Suisun

North Bay

Central Bay

South Bay

Data Uncertainty and Future Development

Certainty of Presence: Generally high.
Certainty of Size: Not applicable (intertidal flat margins are linear features).
Certainty of Location: Medium to low.

Tidal Marsh

Tidal Marsh Bayward Margin
Major Source:
1. United States Coast Survey Topographic Sheets, 1850-1866.

Minor Source:
none

Data Interpretation and Integration: USCS T-sheets clearly depict the lower intertidal limit of vegetation. Historical cartographic data was transferred manually to modern USGS Quadrangle-based basemaps, using persistent physiographic and cultural features for horizontal control.

Tidal Marsh Landward Margin
Major Source
1. United States Coast Survey Topographic Sheets, 1850-1866.

Minor Sources
1. United States Coast Survey Topographic Sheets (1886-1898)
2. Land Grant Surveys
3. Spanish diseños
4. soil surveys and geologic type data
5. local city and county surveys
6. ecological indicators (e.g. willow groves)
7. cultural indicators (e.g. shellmounds)
8. contour data (5' NGVD).

Data Interpretation and Integration
The USCS T-sheets indicate their best estimate of the location of the transition from tidal marsh vegetation to terrestrial vegetation with a solid line and change in symbol type. Where the transition was not obvious, a dashed line was sometimes used. However, the USCS efforts of the 1850's often did not extend to the inland margin of tidal marshlands, notably in most of the broader areas of marshland (e.g. large parts of the North Bay, South Bay, and Suisun Marsh). At sites where marsh reclamation occurred relatively slowly, later T-sheets may be used. All other available data were used (1) to confirm USCS data, and (2) to estimate the most probable location of the Land-Tidal Marsh Margin where USCS data is not available.

We distinguished Low/Mid-Elevation Tidal Marsh from High-Elevation Tidal Marsh by the presence of numerous short, parallel channels, indicative of young, high-gradient systems. Low/Mid-Elevation tidal marshes are adjacent to open bay or larger channels, except in a few places where channels appear to be rapidly downsizing and filling with marsh, and are generally found in places likely to be accreting, such as point bars of channel meanders and the bay edge of the marsh plain.

Muted Tidal Marsh was defined _______

Data Uncertainty and Future Development
Because uncertainty in the extent of historical tidal marsh lies primarily in the position of the landward marsh margin relative to the modern landscape, and because the evidence for this margin generally varies substantially within the same parcel of marsh, historical tidal marshlands were documented by the individual segments of their perimeter, rather than as polygons. The perimeter of tidal marshlands is composed of the bayward and landward margins. Substantial uncertainty exists in some segments of the landward margin. Both bayward and landward margins generally are considered to have possible ranges of location of several hundred feet, and in some cases substantially larger ranges are possible.

It is important to note that the bayward margin between bay water and tidal marshland extends along the sides of the tidal marsh channels which define the bay-marsh intersection. The length of the margin mapped or measured may vary greatly depending on the resolution of the map. Tidal marshes in the Native and Modern Landscape Views of the EcoAtlas are defined by the largest, fifth- or sixth-order channels which extend to the landward tidal marsh margin. Smaller channels have not been depicted at this time; a line has been drawn across these smaller channels at their mouths to define the "marsh edge." We expect that the tidal marshlands represent those present in the early to mid nineteenth century, with the potential omission or false inclusion of possibly some very small (<1 acre) marshes, and substantial uncertainty in some places about the true landward extent of tidal marsh vegetation.

The distinction between Low/Mid- and High-Elevation Tidal Marsh is somewhat uncertain and more research into the relation between channel form and and marsh elevation in larger systems is merited. Since it was not directly defined on the source materials, the presence and size of the Low/Mid-Elevation boundary has Medium level certainty. Some sites of Low/Mid-Elevation Tidal Marsh may not have been apparent due to the limited channel detail shown by surveyors other than Kerr, especially in the areas covered by T-460, T-352, and in the Napa-Sonoma marshlands west of T-777 and north of T-564.

Muted tidal marsh ----

Certainty of Presence: The historical bayward margin of tidal marsh downstream of the Delta is well-documented by maps of the United States Coast Survey circa 1850-1860 and thus nearly always receives high certainty of presence. The historical landward margin of tidal marshland, while less consistently depicted by historical sources, was by definition present at some point inland from the bayward margin, and thus receives a high level of certainty for presence as well. Some very small marshlands are difficult to distinguish on poor quality USCS maps, and receive low certainty for presence.

Certainty of Size: Not applicable (margins are linear features)

Certainty of Location: As the *bayward* margin of tidal marshland is generally well-depicted by relatively accurate historical sources, uncertainty in the location of the bayward margin relative to modern features is primarily related to the process of rectifying historical geographic data to modern map coordinates. Our estimate of the maximum potential horizontal range of location for the bayward tidal marsh margin ranges from +/-200 feet to 500 feet. It is generally larger in Suisun, where early maps were less useful.

The *landward* margin of tidal marshland was often not mapped by the most accurate early surveyors, particularly in the broad marshlands of the South Bay, Napa and Sonoma Creek drainages, and Suisun Marsh. Many other sources of data are available, and have been used to compose the best estimate of historical tidal marsh location in the absence of well-controlled cartographic data or ground-truthing. The transition between high tidal marsh vegetation and terrestrial plant cover which we call the landward margin can also be more gradual and hence more difficult to map than the bayward margin. For these reasons, segments of the landward margin display a wider range of confidence. ***Until specific evidence attributes are attached to segments of the landward margin of tidal marsh, the landward borders of tidal marshland shown in the historical view of the EcoAtlas should be considered as wide transitional zones, extending as much as 2500 feet upslope and downslope of the line shown. Once the attribute files are attached to the line segments, then the accuracy will improve locally. In some places, the margin will have an estimated accuracy of +/- 100 feet or less.***

Tidal Marsh Panne

Major Source

1. United States Coast Survey Topographic Sheets, 1850's.

Minor Sources

1. Later United States Coast Survey Topographic Sheets (resurveys circa 1890s)
2. early USGS maps
3. Land Grant Surveys
4. Spanish diseños
5. aerial photography
6. local surveys
7. written accounts.

Data Interpretation and Integration

USCS data provides highly detailed depictions of panne distribution in much of the tidal marshlands of the Estuary, but leave substantial gaps. Many other sources provide evidence for panne presence, size, and pattern in these areas not covered by the USCS. Local surveys and written accounts are particularly important in Suisun. Additional sources are important for characterizing pannes at the landward tidal marsh margin.

Transitional pannes intercept the land or there is insufficient marsh between land and panne to support a second-order (i.e., persistent) channel system. This protocol identifies pannes which are subject to reduced drainage on their landward margin. All others are drainage divide pannes.

Discussion of Uncertainty and Future Data Development

The tidal marsh panne coverage shows both drainage divide and transitional pannes. It depicts a substantial, but incomplete, portion of the pannes historically present in the Estuary. For many of the large areas where no pannes are shown, no detailed historical data are available, although pannes were likely present.

Pannes smaller than 10 meters in diameter were mapped as points. These have not been compiled in the Native Landscape View at this time. Ponds of this size, or smaller, number in the thousands, especially in the South Bay.

Only one surveyor (David Kerr, USCS) accurately mapped the full size range of tidal marsh pannes. Fortuitously, his team mapped about 1/3 of the marshlands of the Estuary; in these places depiction of ponding pattern in the EcoAtlas is most robust. In other places, the display of pannes may be considered to provide evidence for their general presence, rather than the specific metrics of panne pattern. Islets, or small islands of vegetation within pannes, are shown in a few places by the USCS maps; however, these have not been digitized into the Native Landscape View except in a few cases.

It should be recognized that (1) while confidence in mapped pannes is generally very high, pannes shown vary in certainty of presence, size, and location, and (2) pannes may not be shown in an area in the EcoAtlas because either detailed maps showed their absence, or because no detailed maps were available. The latter case was much more prevalent. Based upon an analysis of panne form in well-mapped parts of the Estuary (Grossinger 1995), an understanding of the relationship of panne size and percent cover to aqueous salinity regime has been developed. This information was applied to estimate the likely total amount of historical tidal marsh pannes in areas not well-represented in historical records.

Certainty of Presence: Mostly high, in some places medium or low.

Certainty of Size: Mostly high, in some places medium or low (defined individually).

Certainty of Location: Mostly high, in some places medium or low.

Some descriptions of tidal marsh pannes in the historical and modern record follow. Historical tidal marsh pannes can be seen at Petaluma Marsh, where in undisturbed drainage systems they are largely unchanged in size and shape (see Grossinger 1995). Recently-formed pannes can be observed at other places in the Estuary, for example at the Emeryville Crescent.

Tidal marsh pannes were called "natural salt ponds" in USFWS and CDFG (1979) and described as follows:

> Both tidal salt pond and natural salt pond habitats are represented by only a few examples. They have essentially the same wildlife uses and values as managed salt ponds. They provide resting sites for various waterbirds and the larger ponds may also be significant feeding areas. Because of the influence of tidal currents they have water qualities similar to adjacent Bay water; however, their protected nature is similar in its role to that of nontidal salt ponds.

Cooper (1926) describes drainage divide pannes in the saline marshlands of the South Bay: "Pools of all sizes occur in the body of the marsh . . . *Jaumea carnosa* (Less.) Gray frequents the borders of pools. . .The vegetation of the pools consists principally of blue-green algae."

Extensive descriptions of transitional tidal marsh pannes are available because of their importance to the early salt industry in the Bay Area. Longtime Bay Area historical researcher A.K. Brown (1960) summarizes some of these references in *Salt for the Scraping:*

> . . . the natural tidal pools [transitional pannes] were overflowed by the high night tides of the early summer, to evaporate over the following months.
>
> These "natural reservoirs" or "tide pools" in the sloughs are what have been hereabouts called hot-ponds. These are in effect shallow mud floored gaps in the salt marsh vegetation, almost never connecting directly with a slough, and classically arranged in a chain along the edge of the hard ground. Such ponds can be filled only by a tide that rises over the level of the marsh, and are emptied only by evaporation; under the constant late-summer winds, they were natural salt-pans. Duflot de Mofras, traveling between Santa Clara and San Francisco in 1842, remarked 'at the roadside large dried lake-beds covered with salty crusts that, from a distance, shine in the sun like enormous snowfields.'

Salt Pond

Major Sources
1. United States Coast Survey Topographic Sheets, 1850's
2. Early salt industry report and documents.

Minor Sources
1. Spanish diseños.

Data Interpretation and Integration
Salt ponds in the Native Landscape View are known areas of native salt production (Crystal Pond) and surface waters in other muted tidal marsh areas in the more saline parts of the Estuary.

Data Uncertainty and Future Development
Substantial uncertainty regarding the origin and character of surface waters in some of the tidal marshes with poor drainage in the North Bay remains. These may have been manipulated by native peoples, particularly where they are near major native village sites such as Olompoli, formed by natural berms or seismic events, or the result of a combination of these causes. We know that native peoples came from as far as Nicasio to get salt "from a place toward Novato - from the bay" (ethnographic notes of Isabel Truesdell Kelly).

Certainty of Presence: High to Low

Certainty of Size: Mostly High.

Certainty of Location: Mostly High.

Lagoon

Major Sources
1. United States Coast Survey Topographic Sheets, 1850's.

Minor Sources
1. Land Grant Surveys
2. Spanish diseños.

Data Interpretation and Integration
USCS T-sheets do not define lagoons directly. However, lagoons can generally be interpreted by their location in the landscape, as surface waters separated from the open bay by narrow beaches. These places are clearly detailed on USCS maps of the Estuary. Additional sources provide confirmation and written description in places (e.g. "laguna salada"), most importantly in places where small lagoons are difficult to distinguish on USCS maps.

Data Uncertainty and Future Development
As a portion of the inner shoreline of the Estuary, lagoons are well-mapped by the early USCS T-sheets for the region (see description of *unvegetated shore, beach*). As a result, the picture of lagoons is geographically robust and generally highly accurate.
Certainty of Presence: Mostly High
Certainty of Size: Mostly High.
Certainty of Location: Mostly High.

Islands

Major Sources
1. United States Coast Survey Topographic Sheets, 1850's
2. early USGS maps.

Minor Sources
?

Data Interpretation and Integration
Islands are landforms surrounded by tidal waters but extending vertically above the extent of the tides. They are often clearly defined on early maps.

Data Uncertainty and Future Development
It is likely that some smaller islands were not identified in areas where historical sources were less detailed.

Certainty of Presence: Mostly High
Certainty of Size: Mostly High.
Certainty of Location: Mostly High.

WATERSHEDS

Moist Grassland

(not included in this release)

Major Source

1. United States Department of Agriculture/U.C. Agricultural Experiment Station Soil Surveys, 1915-1933.

Minor Source

1. USGS Geologic Type Data.

Data Interpretation and Integration: Areas mapped as Moist Grassland in the Native Landscape View of the EcoAtlas are zones of fine-grained alluvial deposits with slow rates of infiltration which received surface or subsurface flow from adjacent, higher lands. They likely supported mostly grassland vegetation with a percentage of shallow low spots which maintained surface water for days or weeks at a time. These low spots might support facultative or obligate wetland plant species. The duration and spatial extent of saturation and surface ponding would be expected to be associated with major rainfall events, in contrast to perennial features whose size can be associated with rainfall year. These shallow low spots are not considered to be the same as vernal pools.

This coverage is compiled primarily from early soil surveys and their accompanying narrative reports, produced by the USDA in conjunction with U.C. Agricultural Experiment Stations. These documents are considered quite accurate in their description of the landscape and are consistently referred to by modern soil scientists and geologists (E. Helley, J. Sowers, pers. comm.). The descriptive text associated with these maps contains sections describing the “Topography and Drainage” for each soil type identified. The presence or absence of surface saturation and/or ponding is noted for each soil type to identify limitations to agricultural development. On the whole, the valleys of the Bay Area are described as “usually well drained and consist[ing] of nearly level to very gently sloping surfaces with occasional minor stream bottoms" (Holmes and Nelson, 1917; p.7). The drainage of the region is further summarized:

> The region in the survey is in general well drained, except for tidal marsh and small basinlike depressions a few square miles in extent south of Santa Rosa and a number of others of less extent elsewhere” (p.9).

Only a small fraction of the total soil types for the region are described as poorly drained; these were selected for the Moist Grassland coverage. The selected types are listed in Table 2.

The poorly drained soils comprising the Moist Grassland coverage coincide generally with the location of Fine-grained Alluvium, as identified in the regional USGS map of surficial geology (Helley, et al., 1979). Fine-grained Alluvium displays characteristics typical of seasonally wet areas:

Distribution and Stratigraphy: Found in poorly drained, nearly horizontal basins between active and abandoned stream levees at the outer margins of alluvial fans adjacent to San Francisco Bay. . .
Origin of deposit: Deposited from standing floodwaters that periodically inundate low interfluvial basin areas and locally form seasonal fresh-water marshes. Presently being formed but depositional processes severely disrupted by modern cultural activity (Helley, et al., 1979; description of type Qhaf).

We compiled several pre-1940 USDA-UCB soil surveys of different areas and/or scales into a single integrated picture. The "Reconnaissance [sic] Soil Survey of San Francisco Bay Region, California" (Holmes and Nelson, 1917) illustrates and describes soil types for the major portion of the watersheds draining to the San Francisco Estuary downstream of the Delta. It was compiled at 1:125,000 scale. The USDA also conducted more detailed surveys (1:62,500) of several areas in the 1930's. We supplemented the earlier source with the more detailed surveys where available. As soil typologies underwent substantial change between the times of the earlier and later surveys, this required determining the correlating soil types. This was done based upon the descriptions of each type and the geographic correspondence between surveys. There was mostly a high degree of correlation. It should be noted that, as a result, the Moist Grassland and Grasslands/Vernal Pool Complexes coverages contain areas of greater and lesser detail, which may affect comparisons of total area between different subregions (for example, somewhat less area in Napa County is identified as poorly drained by Carpenter and Crosby (1933a) than by Holmes and Nelson (1917)).

Table 2. Soil Types Wholly or Partly Used for Moist Grassland Coverage

<table>
<tr><th>S.F. Bay Area exc. Napa and Suisun
(Source: Holmes and Nelson, 1917)</th><th>Suisun Area
(Source: Carpenter and Cosby, 1930)</th></tr>
<tr><td>Dublin adobe soils</td><td rowspan="3">Antioch fine sandy loam
Antioch fine sandy loam, dark-colored phase
Clear Lake clay adobe
Lindsey clay loam
Olcott fine sandy loam
Olcott fine sandy loam, gray phase
Solano fine sandy loam
Solano fine sandy loam, hummocky phase
Yolo silty clay loam, calcareous phase
Yolo silty clay loam, dark-colored phase
Yolo silty clay loam, gray phase
Yolo silty clay loam, poorly-drained phase</td></tr>
<tr><td>Napa Area
(Source: Carpenter and Cosby, 1933a)</td></tr>
<tr><td>Clear Lake adobe clay
Dublin adobe clay
Zamora adobe clay
Zamora silty clay, poorly-drained phase</td></tr>
</table>

Selected soil types were lumped and traced onto mylar, then digitized or scanned. Pre-NAD 1927 coordinates were transformed to NAD 1927 using a geometric coordinate shift developed by Kent Dedrick and Dave Plummer of the California State Lands Commission (Dedrick, 1984?). This adjustment substantially improved registration of the coverages to other historical and modern features. However, registration error of several hundred feet is possible.

In some places, these soil types extended onto substantially sloped surfaces. The coverage was edited to exclude these sites where fine-grained soils are not recent deposits.

In most places around the Estuary, poorly drained soils showed by the early USDA soil surveys occurred adjacent to tidal marshlands. However, when digitized, the soils' extents often did not match the edge of the tidal marsh, which was gathered from other, generally more detailed and earlier sources. In addition to the effects of scale difference, the landward extent of tidal marsh had often been reduced by the time of the soil surveys. To resolve these effects, the downslope edge of Moist Grassland was adjusted to conform to the upslope edge of tidal marsh. This adjustment was limited to places where the soil survey clearly showed the soils extending to the margin of tidal marsh, or the corresponding diked habitat.

It should also be noted, as a result of the Moist Grassland prevalent position at edge of tidal extent, that the soils types likely extended further downslope in recent times and have been submerged by estuarine transgression. In areas with particularly flat underlying topography and where tidal extent has been restricted by artificial levees, additional Moist Grassland may be currently covered by only a thin layer of marsh sediment.

Several places are described as having "stagnated surface drainage" and "hog-wallow topography." These include known sites of vernal pool complexes such as the Laguna de Santa Rosa plain and Jepson Prairie. These places are classified in the EcoAtlas Native Landscape View as Grasslands/Vernal Pool Complexes and described in the Grasslands/Vernal Pool Complexes coverage section. Grasslands/Vernal Pool Complexes are a subset of Moist Grassland displaying specific characteristics associated with vernal pool complexes.

Data Uncertainty and Future Development

The soil surveys used to form a picture of Moist Grassland are regional reconnaissance efforts. Surveyors in the early part of this century had the benefit of seeing large areas unobscured by modern infrastructure, making variations in topography and vegetation more obvious. However, compared to modern soil surveys, these regional efforts moved quickly, presumably with relatively further-spaced soil samples. For this reason the coverage should be considered a coarse estimate of this habitat type. As with all soils maps, boundaries between types cannot be defined precisely and are approximate; therefore the size certainty of Moist Grassland patches is medium (potential uncertainty of +/-50%). More detailed pictures should be developed locally.

An additional USDA soil survey of Contra Costa County (Carpenter and Cosby, 1933b) has been acquired and will be used in a future version of the EcoAtlas.

The extent of seasonal ponding associated with the Moist Grassland would be expected to vary substantially between places and years. Descriptions of the soil types range from "covered with water for weeks or months" to "following heavy rains the land is boggy in most places" to "subdrainage poor" and "poorly drained flats." Omissions of some small areas and some local inaccuracies are likely to be present in this coverage.

Certainty of Presence: High
Certainty of Size: Medium

Certainty of Location: Medium

Grasslands/Vernal Pool Complexes
(not included in this release)

Major Sources
1. United States Department of Agriculture/UC Agricultural Experiment Station Soil Surveys, 1915-1933.
2. Field investigation of modern vernal pool complexes.

Data Interpretation and Integration
A subset of places identified as Moist Grassland (see Moist Grassland description above) were described in the original source materials as having unusual topography consistent with vernal pool or "hog-wallow" features. Those places which were described as having poor surface and subsurface drainage, and "hog-wallow topography," are classified in the EcoAtlas Native Landscape View as Grasslands/Vernal Pool Complexes . "Hog-wallow" is a traditional term used to describe the repeating undulations in topography associated with vernal pool complexes and is a strong descriptive indicator of potential vernal pool topography. "Mima mound" is a synonym for "hog-wallow" that appears in more modern documents. The places described this way in the USDA soil surveys include known regions of vernal pool complexes such as the Laguna de Santa Rosa plain, Jepson Prairie, and the Bay margin near Fremont. Because Grasslands/Vernal Pool Complexes are extremely old, observation of present-day vernal pool complexes provides strong evidence for their historical existence.

The Grasslands/Vernal Pool Complexes coverage represents fine-grained alluvial deposits which likely supported coastal prairie vegetation with a percentage of low spots which maintained surface water for extended periods. These low spots probably supported facultative or obligate wetland and vernal pool plant species.

Three discrete areas of Historical Grasslands/Vernal Pool Complexes are identified within the extent of the EcoAtlas: (1) adjacent to the northern and western edges of Suisun Marsh; (2) west of the lower reaches of Sonoma Creek, and (3) near Newark. Evidence for these sites is summarized in the following section, and the soil types corresponding to these data are listed in Table 3.

1. Adjacent to Suisun Marsh
The "Reconnaissance [sic] Soil Survey of the Sacramento Valley, California" (Holmes, et al., 1915) shows Solano loam and clay loam as covering for several miles almost all of the flatlands on the northeast border of Suisun marsh near Potrero Hills. This soil type is described as follows:

> A rather marked tendency toward a "hog-wallow" surface is apparent over much of the group, being in parts of the clay loam very pronounced. Surface drainage is only fair and in nearly all instances the subdrainage is very poor, causing the subsoil to have a mottled appearance.

The type is also described as "not easily tilled" and having spots with "pronounced adobe structure . . . in poorly drained local flats."

The western margin of the Holmes, et al. (1915) survey is the line of 122@ longitude (U.S. Standard Datum 1910) which intersects Potrero Hills. Holmes and Nelson (1917) adjoins and indicates Solano loam and clay loam as extending slightly further west, to near Laurel Creek. The eastern margin of Suisun Marsh is bordered primarily by Solano loam and clay loam and Antioch loam and clay loam, which is described as having “a few flattened depressions where water accumulates for short periods. Sufficient alkali to prevent the growth of crops is found in the area bordering the Montezuma Hills.”

The above data, compiled at 1:125,000 scale correlate well to soil types described as poorly drained in the later Soil Survey of the Suisun Area (Carpenter and Crosby, 1930), compiled at 1:62,500. The latter soil types were thus used to provide more spatially resolute data in the Solano County portion of the Grasslands/Vernal Pool Complexes coverage.

These data are well-corroborated by the current presence of vernal pool complexes on these soils north of Potrero Hills, in Jepson Prairie, and on the western side of Montezuma Hills. Therefore these places receive a High certainty for Presence for historical Grasslands/Vernal Pool Complexes .

2. West of Sonoma Creek

Holmes and Nelson, 1917 (pp.90-91) describe a hardpan, hummocky and hog-wallow topography, and restricted drainage. The Madera Series Loams and Clay Loams are described as follows:

> [The hardpan] varies in thickness and character from a few inches of distinctly cemented impenetrable hardpan to thicker layers of less thoroughly cemented material. . . The surface is uneven, owing to hummocks and small depressions . . .Drainage is restricted during the rainy season, owing both to the depressions and to retardation of underdrainage by the hardpan.
> Topography and Drainage–The surface is usually quite uneven, owing to the presence of numerous small mounds and intervening depressions, sometimes known as hog wallows.

Only one patch of Madera Loams and Clay Loams occurs within the extent of the EcoAtlas–adjacent to the lower reach of Sonoma Creek. Present-day vernal pool complexes have been identified in this area and in the other large area of Madera soils shown on the USDA map, the Laguna Santa Rosa area. Therefore this place receives a High certainty for Presence.

3. Near Newark

Holmes and Nelson, 1917 (pp.90-91; description of Yolo Clays):

> “In the vicinity of Newark the poorly drained areas of this group occupy the lower slopes of alluvial fans where they gradually descend into the Tidal marsh . . .A great part of these areas has a hog-wallow surface, carries much alkali, and is of little agricultural value.”
> “These soils occupy the flatter parts of alluvial fans and valley bottoms, and except in the case of the areas with a hog-wallow surface near Newark, they are comparatively smooth.”

There are three polygons or patches of Yolo Clays in the vicinity of Newark in the corresponding USDA map. Holmes and Nelson (1917) supports vernal pool soil characteristics in these three places. Based upon modern evidence of present day vernal pool characteristics, the eastern-most site has been classified by SFEI as having a High certainty of Presence. The neighboring sites to the west receive a Medium certainty for Presence because they are suggested by historical data but have not been corroborated by present-day observations.

Table 3. Soil Types Wholly or Partly Used for Grasslands/Vernal Pool Complexes Coverage

Suisun Area (Source: Carpenter and Cosby, 1930)	Sonoma and Newark Areas (Source: Holmes and Nelson, 1917)
Antioch fine sandy loam	Madera loams and clay loams
Antioch fine sandy loam, dark-colored phase	Yolo clays
Clear Lake clay adobe	
Lindsey clay loam	
Olcott fine sandy loam	
Olcott fine sandy loam, gray phase	
Solano fine sandy loam	
Solano fine sandy loam, hummocky phase	
Yolo silty clay loam, dark-colored phase	

Selected soil types were lumped and traced onto mylar, then digitized or scanned. Pre-NAD 1927 coordinates were transformed to NAD 1927 using a geometric coordinate shift developed by Kent Dedrick and Dave Plummer of the California State Lands Commission (Dedrick, 1984). This adjustment substantially improved registration of the coverages to other historical and modern features. However, registration error of several hundred feet is possible.

In some places, these soil types extended onto substantially sloped surfaces. The coverage was edited to exclude these sites where local topography would preclude seasonal ponding.

In most places around the Estuary, Grasslands/Vernal Pool Complexes as evidenced by the early USDA soil surveys occurred adjacent to tidal marshlands. However, when digitized, the coverage's extents often did not match the edge of the tidal marsh, which was gathered from other, generally more detailed and earlier sources. In addition to the effects of scale difference, land uses had reduced the landward extent of tidal marsh by the time of the soil surveys. To resolve these effects, the downslope edge of Grasslands/Vernal Pool Complexes was adjusted to conform to the upslope edge of tidal marsh. This adjustment was limited to places where the soil survey clearly showed the soils extending to the margin of tidal marsh, or the corresponding diked habitat.

It should also be noted, as a result of these soil types' prevalent position at edge of tidal extent, that the soils likely extend further downslope and have been submerged by estuarine transgression. In areas with particularly flat underlying topography and where tidal extent has been restricted by artificial levees, some soils historically supporting vernal pool complexes may currently be covered by only a thin layer of marsh sediment.

Data Uncertainty and Future Development

The soil surveys used to form a picture of Grasslands/Vernal Pool Complexes are regional reconnaissance efforts. Surveyors in the early part of this century had the benefit of seeing large areas unobscured by modern infrastructure, making variations in topography and vegetation more obvious. However, compared to modern soil surveys, these regional efforts moved quickly, presumably with relatively further-spaced soil samples. For this reason the coverage should be considered a coarse estimate of this habitat type. As with all soils maps, boundaries between types cannot be defined precisely and are approximate; therefore the size certainty of Grasslands/Vernal Pool Complexes patches is medium (potential uncertainty of +/-50%).

Holmes and Nelson (1917) note that additional areas of Madera Loams and Clay Loams might be identified by detailed examinations of the Pleasanton loams southwest of Sonoma and Shellville, and the Antioch loam and clay loam south of San Pablo. “A slight hog-wallow topography” is also noted north of Napa, but here drainage is described as “adequate” (Holmes and Nelson, 1917). It is occasionally mentioned that within a larger soil type there are small, unidentified areas with particularly poor drainage and alkali accumulation which limit agriculture. Additional small, local areas of Grasslands/Vernal Pool Complexes (e.g. near Miller Creek in Marin County, at Mayfield in Santa Clara County) are likely in both the historical and modern landscape. More detailed pictures may be developed locally. Omissions of some small areas of Grasslands/Vernal Pool Complexes and some local inaccuracies are likely to be present in this coverage. Determination of current or potential future vernal pool function requires field investigation.

Certainty of Presence: High to Medium
Certainty of Size: Medium
Certainty of Location: Medium

Vernal Pools

Major Source
1. United States Geological Survey 15' Quadrangles, 1890's to 1930's.

Minor Sources
none

Data Interpretation and Integration
Vernal pools are identified on early USGS maps by symbols indicating ephemeral standing water.

Data Uncertainty and Future Development
Historical data depicting individual vernal pools in the Bay Area appears to be limited to the Suisun area, extending to the greater Sacramento Valley. The few pools which are available in the historical record are shown in this coverage. Additional currently or recently existing natural (and presumably historical) vernal pool complexes might be added to this coverage. This coverage should be considered a highly incomplete map of historical vernal pools. It should be used in concert with the coverage of Grasslands/Vernal Pool Complexes , which is more regionally representative.

Certainty of Presence: High
Certainty of Size: High
Certainty of Location: High

Perennial Pond

Major Sources
1. Spanish Diseños
2. United States Geological Survey 15' Quadrangles, 1890's to 1930's.

Minor Sources
1. Written accounts
2. United States Coast Survey Topographic Sheets, 1850's
3. Land Grant Surveys.

Data Interpretation and Integration
Freshwater resources have always been important to the survival of human inhabitants of the semi-arid Bay Area. They were therefore a major landmark in the historical landscape and routinely indicated on Spanish diseños and by early explorers assessing locations for missions and towns. These sources do not always provide accurate evidence for size, however, resulting in low levels of certainty associated with the size and location of some features. These qualifications are noted in the associated attribute tables of the coverage. In many places, however, well-controlled size and location for persistent palustrine features is obtained from the USCS sheets or later USGS maps. In contrast, freshwater resources were of relatively small importance to coastal navigation, the primary objective of the USCS, and are not mapped consistently by the USCS. In particular, the black-line

symbols of the USCS maps of the Bay Area do not always clearly distinguish topographic lows (which may be lakes or ponds) from highs, or hills. Integration of both USCS and Spanish source data is necessary to interpret the historical distribution of perennial surface waters.

Data Uncertainty and Future Development

This coverage includes freshwater ponds, lakes, and marshes that are expected to maintain standing water throughout an average rainfall year. The size shown is the maximum extent supported by the evidence. For example, where surface waters are shown with surrounding emergent vegetation, a polygon is drawn to encompass the entire feature, delineating the probable maximum annual extent of surface water at the site. Surface water resources are expected to display substantial annual variability; the Native Landscape View shows a composite picture representing a best estimate of average condition for a range of years (1770-1900).

Willow Grove

Major Sources
Spanish diseños
Land Grant Surveys
United States Coast Survey Topographic Sheets, 1850's.

Minor Sources
Later USCS T-sheets; Local Surveys; written accounts.

Data Interpretation and Integration: This coverage is the willow-dominated wooded areas adjacent to the baylands on the low-gradient alluvial plains of the Bay Area. Willow groves are described alternately as "sausals," "willow marshes," and "willow swamps" in the historical record. A variety of different spellings of *sausal* (*sauzal, saucel*, etc.) are found, as well as references to the diminutive form, *sausalito*.
Sausals were a major physical and ecological landmark in the historical landscape and are routinely indicated on Spanish diseños. They are usually identified with the word "sausal." Many local and Land-Grant surveys also identify these places as "willow marsh," or "willow swamp," to distinguish between other woodlands shown with the same tree symbol. This habitat type has been described in the local historical plant ecology literature as the "Moist Soil Willow Community" (Clarke 1952) or as a component of the "Willow-Composite Community" (Cooper 1926). Sausal seems to be the most common locally used term.

Cooper, writing in 1926, describes sausal remnants in the South Bay as follows:

> Locally, where the water table is almost at the surface, a very different group of plants [from the Composites described immediately preceding] still maintain themselves in practically natural condition. The Arroyo Willow (*Salix laseolepis* Benth.) forms rather dense thickets sometimes 30 feet in height. Cottonwood (*Populus trichocarpa* T. and G.) is second in abundance, and Box Elder (*Acer negundo californicum* (T. and G.) Sarg.) and Oregon Ash (*Fraximun oregona* Nutt.) also occur. The shade is heavy. Several shrubs are characteristic, the most important being the Blackberry (*Rubus vitifolius* C. and S.), which clambers over everything, even going into the branches of the trees to a height of 15 feet. Rosa californica and Ninebark (*Physocarpus capitatus* (Pursh) Ktze.) are also common. According to the testimony of old residents much of the original willow thicket has been destroyed by cutting.

Cooper associates the Willow-Composite Community with freshwater-saturated Adobe soils (see description of Moist Grassland).

Clarke, in a 1952 reconstruction of historical Bay Area plant communities, describes the Moist Soil Willow Community as the only community which "is now almost, if not totally, destroyed." Clarke distinguishes Riparian Community and Moist Soil Willow Community and discusses the non-obligate riparian distribution of *S. laseolepis*.

Mayfield (1978) describes the community similarly: ". . .in wet places near springs or by the salt marshes grew "sausals," or willow groves. . ."

Historical reconstruction of this habitat type relies on a variety of documents. The diseños, while providing strong descriptive evidence for the presence of a sausal, do not generally show size and location to a high level of confidence. In these cases, well-controlled spatial data for sausals is often obtained from the USCS sheets, which do not differentiate by tree types. Where they are not identified by words, areas of tree symbols may be deduced to represent sausals by their shape (generally round) and location (immediately adjacent to tidal marsh margin or freshwater pond), most confidently where overlap between two sources at other sites has confirmed such relationships.

In the most detailed depictions of sausals, springs, ponds, or marshes are shown within the wooded area. Based on these data, and the descriptive terms "willow swamp" and "willow marsh" it is likely that, in places, perennial pond constitutes a minor type within sausal.

Data Uncertainty and Future Development

Sausals are found in the historical record in at least some parts of all subregions of the Bay Area. However, they are almost absent from most of the North Bay and Suisun. This apparent subregional difference could conceivably be an artifact caused by the fewer documents of Spanish origin north of the Golden Gate and Carquinez Straits. Or the difference could be real and reflect the influence of natural habitat controls and native land uses. The latter cause would relate to subregional differences in the cultural significance of willows as a natural resource. However, enough documents are available, with some scattered evidence for sausals, that it seems more likely that the subregional differences elucidated through the historical record are representative of natural conditions. Future local research may provide a better understanding of the relative influence of these factors on sausal distribution in the historical landscape.

Certainty of Presence: High to Low, mostly High and Medium.
Certainty of Size: High to Low, mostly High and Medium.
Certainty of Location: High to Low, mostly High and Medium.

Riparian Forest

Major Sources
Spanish diseños
written accounts
United States Coast Survey Topographic Sheets, 1850's

Minor Sources
Later USCS T-sheets
Local Surveys

Data Interpretation and Integration
This coverage shows historical riparian forest of the alluvial plains adjacent to the baylands. Early USGS Surveys and most local maps do not describe riparian features. However, both Spanish diseños and early explorers' journals make careful note of the extent of trees along creeks, as potential timber sources and, in particular, as landmarks. For both these purposes a distinction appears to have been made between the low vegetation which was probably ubiquitously tucked into the incised creek channels of the region and mature tree stands which could distinguish one creek from another and potential mission sites with nearby timber resources from those without. These riparian tree stands comprise the Riparian Forest coverage.

On diseños, riparian forest is shown pictographically, as a row of single trees along both sides of a creek. While the extent of riparian forest along the sloping alluvial plain is probably meaningful (see below), few attempts were made historically to show accurately the width of the tree stands, beyond the indication of a narrow, "one-tree wide" zone. In these cases, riparian forest is shown in the EcoAtlas as a linear feature in an arc coverage. Where historical sources do appear to show accurately the actual width and shape of riparian features, then that shape is shown in a polygon coverage to the level of detail available, to individual trees where possible, with a minimum resolution of about 75 feet.
Diseños generally distinguish between corridors of trees extending the full length of the creek and those ending at some point on the alluvial plain. The endpoint of these riparian forests can generally be estimated by relationships to other features. For example, a diseño may show whether or not the creek-crossings of an early road pass though trees or not; the early road can generally be identified and is often still present (e.g., E. 14th St. and Mission Blvd. in Alameda County, El Camino Real in San Mateo County). Through these methods of registration, the topographic extent of riparian forest can be distinguished with varying levels of certainty.

Data Uncertainty and Future Development
A substantial amount of historical data indicating riparian trees along creeks was found, and a fairly detailed picture has been developed. However, it is likely that some sections of creeks additional to the ones indicated had tree canopies. Uncertainty about the riparian character of creeks is generally greater further away from the baylands, and in the northern parts of the Estuary (e.g. tributaries of Napa and Sonoma Creeks, Marin Creeks), where Spanish documents (diseños and explorers journals) are less illustrative.

As would be expected, riparian trees on the alluvial plain are more common with distance upslope, as perennial water flow presumably increases. Mapping the riparian trees of the flatlands thus becomes a question of the topographic extent of trees along a given creek, in particular the downstream extent. The picture of riparian trees is robust with regard to the lower alluvial plain in a regional context. Gaps in the data are likely of local significance and increase away from the baylands. These gaps may be filled by locally-based research, with substantial detail in riparian plant community composition including subregional differences possible.

Two additional steps were necessary to estimate the likely total amount of riparian forest by subregion in light of the above uncertainties in Version 1.50 spatial analysis.

(1) The greatest uncertainty is associated with determining the proportion of historical riparian forest unaccounted for in the Native Landscape View. While more detailed information is currently being developed through local Historical Ecology Projects, a preliminary estimate was made by comparing Riparian Forest mapped in the Modern Landscape View to that in the Native Landscape View. This comparison suggested that in some regions most of the historical riparian forest was likely accounted for, while in others substantially greater amounts were likely present than were identified through the historical sources which have been used. The factors used to infer likely approximate totals are listed below.

(2) To estimate the area of riparian forest mapped as arcs, we determined an average width for riparian forest based upon modern remnants which do not appear to be reduced in width by urbanization. The area of X mile? long patches of riparian forest was divided by the corresponding length of creek. The average width based upon X measurements on X,X,X, and X creeks was 40 m. We then created a buffer polygon of 20 m on each side of the creek channel and summed this area with that of historical riparian forest polygons.

Some samples of Riparian Forest descriptions in the historical record follow:
San Leandro Creek:
“. . .we came to an arroyo with little water but with a very deep bed grown with cottonwoods, live oaks, laurels, and other trees, crossing it at the foot of the hills" (Pedro Font, April 1, 1776).

Sanjon de los Alisos (old, southern-most channel of Alameda Creek):
“. . . were faced with a creek to be crossed, all lined with sycamores and other trees, with no water in it . .” (Fages, November 27, 1770). (Sanjon de los Alisos means "the big ditch of the sycamores" (Mosier and Mosier 1986)

Certainty of Presence
For riparian forest, presence refers to the presence of tall trees within the riparian zone of a creek, or certain segment of creek. Several common situations were noted:
(1) Creeks with attendant trees noted at the base of the hills, and not further downslope– these are generally small creeks. In these cases where riparian character appears to be associated more with the uplands than the flatlands, the feature is mapped as riparian trees, with the notation "ravine-influenced" in the database.
(2) A downstream section of a creek has well-documented (certainty of presence = High) riparian tree stands, but no sources are available for the section upstream; in these cases,

it is assumed that the corridor of trees continued upslope along the creek. The extrapolated section is qualified with medium presence and noted in the database.

Certainty of Size
Spanish diseños, the most important source for riparian trees, do not attempt to accurately depict the width of the forest, beyond the indication of a narrow, one tree wide zone. In these cases riparian trees are shown as linear features with no size attribute. In the cases where larger-scale sources (generally USCS) do appear to show the actual width or shape of riparian features, that shape is shown to the level of detail available, to individual trees where possible. Certainty is high to medium where the width of the zone of riparian trees width is noted.

Certainty of Location: Same as creek (see description of creek location).

Lowland Rivers and Creeks

Major Sources
Local surveys
United States Geological Survey 15’ Quadrangles, 1890’s to 1930’s

Minor Sources
United States Coast Survey Topographic Sheets, 1850’s
later USCS T-sheets
Land Grant Surveys
Spanish diseños

Data Interpretation and Integration
A wide range of historical and modern sources were used to produce a picture of fluvial resources of the alluvial plains adjacent to the Estuary. The picture shown here is intended to provide a context for study of the Baylands, rather than a detailed reconstruction of historical fluvial hydrology. Substantial uncertainty is associated with, for example, the local details of watershed drainage networks and the distribution of springs. Additional sources exist to develop more resolution on a watershed-by-watershed basis. Historical creek courses in this coverage should be regarded as subregional approximations of complex and changing systems. Differing historical materials often show different creek patterns. Where historical data confidently shows creek courses different from, or not shown by, the modern USGS 7.5’ Quadrangles, the earliest well-documented historical course is used. In many cases, several historical sources are used for different parts of a creek system. Where no significantly different and/or well-controlled historical data for a creek course is available, the modern course as shown on the USGS quadrangle is used. Where creeks are well-represented as polygons on authoritative historical maps at 1:24,000 scale, the polygons have been digitized into the EcoAtlas. Otherwise, creeks are shown as single lines.

Data Uncertainty and Future Development
Creek courses should be regarded as subregional approximations of complex and changing systems. Differing materials often show different creek patterns.
In some cases, early documents indicate no creek course connection to the Bay or tidal marsh, often showing a trifurcation or “fan” at the downslope channel end, even though later sources might show instead a straight connection (often as a straight channel) to tidal areas. In this case, as others, the earlier condition is shown on the EcoAtlas. Deeply incised creek channels in upstream reaches may lead to aggradation downstream, with the channel spreading out into seasonally wet washes, willow groves, or draining through the subsurface. For example, the early USDA soil survey of the Sacramento Valley (Holmes, et al., 1915) describes a soil group along the lower plains along the Contra Costa shoreline:

> Some of the region near Antioch has a rolling topography, but most of it is but little diversified, except by streams issuing from the hilly region to the south and entering the group in deep channels. As these waterways reach the lower levels of the plain they become less accentuated and in the lower margin may appear as shallow washes.

Carpenter and Cosby (1933a), in another early soil survey, describe similar conditions in the Napa Valley:

The main streams in most of the valleys are incised between steep walls of alluvium, with tributary streams occupying shallow channels as they emerge from the mountains. Continuing down the slope they discharge run-off in radiating surface channels, and finally the water spreads as a sheet over the lower parts of the fans, flooding the valley plain in times of rapid run-off.

This coverage encompasses five fluvial feature types: creeks flowing to the Bay; creeks not flowing to the Bay; wet fans; spring runs; and springs. These have been compiled independently with distinct documentation for each feature but are presented here as a general, inclusive coverage.

Certainty of Presence: Mostly High or Medium
Certainty of Size: not applicable
Certainty of Location: Mostly High or Medium

Some Questionable Places in the Native Landscape View

This section introduces discussion of several unusual Bay Area places, or places representing large gaps in data. It is hoped that these brief summaries of these places will increase the likelihood that additional information will be developed to clarify their interpretation.

1. Suisun Marsh

Because detailed USCS maps of Suisun Marsh prior to land use changes are not available, the EcoAtlas Native Landscape View for this area is somewhat more speculative and less resolute than in other marshlands in the Bay Area. However, through extensive local research by SFEI and historian Tony Arnold, of the Teal Club, a variety of data have been recovered regarding the early character of Suisun Marsh. Together these produce a reasonably clear picture with substantial detail in some places.

Despite the absence of tidal marsh pannes in Suisun today, it is clear that these were historically a significant feature of the marshland. Natural tidal marsh pannes in the western part of Suisun (e.g., Joyce Island and further west) were the original sites of duck clubs. The pannes were called ponds and had names, chosen for the hunters who shot there or the type of waterfowl for which the pond was known. These early names became the names of duck clubs. With Dr. Arnold's assistance, we have compiled a map of natural duck ponds of western Suisun.

While a composite picture of the western parts of the marsh can be substantially reconstructed from turn-of-the-century town surveys and club property documents, information describing natural habitats of the marshlands east of Suisun Slough is less forthcoming. The eastern and western parts of Suisun Marsh display distinctly different histories of development. Eastern Suisun developed more slowly and was converted to agriculture before duck clubs, in contrast to western Suisun.

One possible explanation for the differences depicted between east and west Suisun marshes is that they really were different, the eastern side supporting fewer pannes and less abundant waterfowl populations. The second possible explanation has to do with culture and location. Western Suisun was influenced to a greater degree by market hunting and subsequent sport hunting because it was closer to the urban centers of the Bay Area:

"Grizzly Island was a long way from anywhere" (Arnold 1996);

"The Montezuma marshes are also good sporting grounds, but they are little used because there is no way to get at them except by boat" (The Breeder and Sportsman 1882, in Arnold 1996).

Because of its proximity to market, western Suisun may have been more highly regarded for waterfowl.

Some evidence for waterfowl support in pannes of eastern Suisun marshlands is listed below.

a. An account of duck hunting in the "phantom pond" in 1882 can be confidently located in Grizzly Island ("an island some fifteen miles long by from one to five miles wide" in Suisun Marsh). This account, retold by George Bird Grinnell and reprinted in *Ducks Unlimited* (1992) describes a "small," "nearly circular" pond of "about 150 yards in diameter." The pond was renowned for its birds:

. . . we commenced to hear the peculiar noise which a large flock of wildfowl make while feeding in a pond–that is, a continued splash from their unceased diving.

. . . soon a beautiful pond stretched out before us, just completely covered with wildfowl of every description.

. . . I know we got nineteen Canada honkers, tremendous fellows; about two dozen white geese, a dozen ordinary gray geese, one swan, and I will not state how many ducks, as I suppose I might shock my Eastern friends . . .

b. An account cited by Arnold (1996) describes "a superb sprig pond with thousands of birds" on Grizzly Island in 1898.

c. A panne is clearly shown on Grizzly Island by USGS (Karquinez Quadrangle, 1898). This may be the same feature as the Phantom Pond.

d. Evidence with a low level of certainty is provided by modern topographic maps, which show depressions in the eastern parts of Grizzly Island of similar shape, size, and location to pannes to the west and south.

e. In an 1887 description of Solano County, Suisun Marsh is described with regard to current and potential use for pasturage and dairy. The account appears to describe natural pannes with abundant waterfowl as a general feature of Suisun Marsh. The account refers to Suisun Marsh as a whole, mentioning Suisun, Montezuma, Cordelia, and Nurse's Sloughs, with no distinctions made between the eastern and western parts. It should be noted that the account was issued by the Solano County Board of Trade and the description of the marsh was likely intended to encourage agricultural use of the less-developed eastern side of Suisun.

The marsh or tule lands bordering on Suisun bay and extending inland about 16 or 17 miles are difficult of accurate description. For pasturage or dairy purposes, they certainly stand at the head, especially during the summer months. The soil is of vegetable growth mixed with the sedimentary debris which has come down the Sacramento and San Joaquin rivers for ages beyond the memory of man, mixed with upland washings and manured by the deposits of guano left among the rushes and margins of the ponds by the vast flocks of wild fowl and aquatic birds which have hovered over them for untold cycles . . .

The marsh to both the west and the south of eastern Suisun area has well-documented historical tidal marsh drainage divide pannes of consistent size and pattern. Drainage divide pannes are found historically in western Suisun from the bay edge to the top of Suisun and Cordelia sloughs. They are also observed in the marshes of the Contra Costa County shores south of eastern Suisun, and at Brown's Island, slightly upstream. Pannes are also observed throughout the rest of the Bay Area. The observed size class distribution of these pannes is similar to brackish aqueous salinity conditions observed in other part of the Estuary (Grossinger 1995), as would be expected for Suisun. In addition, natural transitional pannes are well-documented along the upland margin of Eastern Suisun.

Summary
It appears that a strong reason for lack of early hunting and resultant mapping of waterfowl habitats in eastern Suisun was the lack of easy access provided by railroads and adjacent lands, rather than differences in tidal marsh form. Substantial data describe historical tidal marsh pannes and waterfowl use of such features in eastern Suisun; however, a robust picture of historical conditions has not emerged.

In addition to these general historical accounts, it is important to remember that specific historical events, such as the demand for waterfowl in San Francisco restaurants in the late 1800's or the overseas demand for grain from California in the 1930's, can initiate long-term land-use practices. These may not be directly based in the character of the land, and may long outlive the initial impetus for conversion. Further research will be needed to clarify the history of the region and historical variations in tidal marsh form within the greater Suisun Marsh.

2. Upper Napa Creek Marsh
Two very large pannes are clearly shown by the USCS (1858) at the mouth of Napa Creek where it enters tidal marshland. These are unusual because (1) two straight channels connect one of the ponds and the creek, and (2) the inner area of the ponds displays a cartographic symbol for marsh not used in any other tidal marshlands in the Estuary. For these reasons they have not been included in the analysis of tidal marsh metrics and freshwater inputs. However, they may be important features, because of their potential waterfowl support functions and their illustration of freshwater-influenced tidal marshland.

The site is notable also because it would be expected to be among the freshest points of marsh in the Bay Area downstream of the Delta. Napa Creek was the second-largest creek in the Bay Area. Detailed maps do not extend to the mouth of Alameda Creek, the only larger creek, so upper Napa Creek provides one of our best pictures of natural fresh tidal marsh downstream of the Delta.

The most likely explanation for the unique depiction of the two pond features is that they are natural tidal marsh pannes, of a large size because of poor drainage at the upland margin of a large vegetated marsh plain with almost no channels (see Grossinger 1995). Emergent vegetation may be present here but not in most other tidal marsh pannes because of the fresher conditions. The channels may indicate an attempt to drain the pannes and marsh for reclamation--improved drainage then allowing revegetation of the pannes--or evidence of early duck pond manipulation by hunters (cut channels, weirs, sluice gates), as is commonly seen in pannes in the 1800s in Suisun and currently in Petaluma Marsh. The map shows significant agriculture and road construction by this time, so impacts are not unlikely. Fuller understanding of these ponds is likely available through local archives.

3. Elevated Lagunas in the North Bay and Other Nearby Wetlands
In this study, we collected evidence for palustrine wetland features of the alluvial plains adjacent to the Estuary and extending upslope to the base of the hills. Some freshwater

features of potential significance to Estuary resources were observed beyond this artificial boundary.

Most notable were three large lakes or "lagunas," each found at 200-220' elevation and 37º 13' latitude in North Bay hills fairly close to the Bay. These include the historical Lake Tolay, in the hills between the Petaluma and Sonoma Creek marshlands, Laguna San Antonio (no longer present) and Laguna Lake (still present) in the Marin hills west of San Antonio Creek. No similar features are found in the hills around the Bay. Each of these perennial surface waters is much larger than the combined size of all documented historical North Bay surface waters of the alluvial plain.

Closest to the Estuary was Lake Tolay. Archaeological research has suggested that Lake Tolay was a "large, shallow pond" with important waterfowl resources for native peoples (Elsasser 1955). Extensive archaeological artifacts have been found at the site (Spectrum Northwest 1978).

Large natural lakes are not found in the hills in other parts of the Bay Area. Sites of palustrine wetlands beyond the base of the hills, but not far from the Bay, include the current Calaveras Reservoir, Chabot Reservoir, Crystal Lake Reservoir, and the substantial wetlands in the Dublin/Livermore area.

4. Wetlands in San Francisco Sand Dunes

Fairly strong cartographic evidence (City of San Francisco, USCS 1852) shows freshwater marsh with trees in low spots of the San Francisco dunes, towards their eastern edge, where they meet the tidal wetlands of Mission Bay. These are currently classified as a subset of sausals, because willows are the likely tree species that was supported, but the sandy substrate is distinct from the fine grained alluvial soils typically supporting sausals.

5. Trees in Tidal Marsh

In several places in historical San Francisco and Marin tidal marshland, tree symbols are observed interspersed with tidal marsh symbols. The trees are not shown as occupying small hills or shellmounds. The meaning of the combination of symbols is a mystery.

6. Unusually Large Tidal Marsh Pannes

Unusually large tidal marsh pannes are well-documented historically near present-day Novato and Hayward. It has been suggested that these pannes were created and/or managed by native peoples for hunting waterfowl and/or harvesting salt.

THE ECOATLAS MODERN LANDSCAPE VIEW

(documentation for all coverages in progress)

Modern Large Areas of Moist Grassland

(not included in this release)

Present-day places within the extent of the Historical Moist Grassland coverage may still provide Moist Grassland functions, depending on historical and current land use practices. To provide an indication of areas which might still support these functions, a modern coverage was created. The coverage called Modern Large Areas of Moist Grassland (MLAMG) indicates the portions of the historical coverage which are not presently developed (polygons less than 20% covered by built structures (including building, roads, parking lots, and salt crystallizers) or undeveloped parts of polygons greater than one square mile; developed areas larger than 50 acres within selected polygons were removed). Extent of development was assessed using the 1995/96 NASA IR photography also used for other habitat types of the Modern View. Places in the MLAMG coverage might not currently provide seep or wet soil functions. However, they are indicated by historical data as having a strong likelihood of providing these functions. Assessment of actual current, or potential future, moist grassland soil function will require field investigation.

Certainty of Presence: Medium (Field investigation required to establish Presence)
Certainty of Size: Medium (Field investigation required to establish Extent)
Certainty of Location: Medium

Modern Large Areas of Grasslands/Vernal Pool Complexes

(not included in this release)

Present-day places within the extent of the Historical Grasslands/Vernal Pool Complexes coverage may still provide vernal pool functions, depending on historical and current land use practices. To provide an indication of areas which might still support vernal pools, a modern coverage was created. The coverage called Modern Large Areas of Grasslands/Vernal Pool Complexes (MLAVPS) indicates the portions of the historical coverage which are not presently developed (polygons less than 20% covered by built structures (including building, roads, parking lots, and salt crystallizers) or undeveloped parts of polygons greater than one square mile; developed areas larger than 50 acres within selected polygons were removed). Extent of development was assessed using the 1995/96 NASA IR photography also used for other habitat types of the Modern View. Places in the MLAVPS coverage might not currently provide vernal pool functions. However, they are indicated by historical data as having a strong likelihood of providing these functions. Assessment of actual current, or potential future, vernal pool function will require field investigation.

Certainty of Presence: High (Field investigation *recommended* to establish Presence) to Medium (Field investigation *required* to establish Presence)

Certainty of Size: Medium (Field investigation required to establish extent)
Certainty of Location: Medium

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